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**BET BIG ON DOUBLES, BET SMALLER ON TRIPLES.  
EXPLORING SCOPE ECONOMIES IN MULTI-SERVICE  
PASSENGER TRANSPORT COMPANIES**

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**Abstract**

In this paper, using a sample of Italian bus and coach operators, we investigate the presence and the magnitude of scale and scope economies in the provision of passenger transport services. The estimates of a Composite Cost Function econometric model highlight the presence of global *scope* and *scale* economies only for multi-service operators (providing urban, intercity and for-hire bus and coach transport services) with output levels lower than the ones characterising the ‘average’ firm. This indicates that relatively small, specialised companies would benefit from cost reductions by evolving into multi-service firms providing urban, intercity and coach renting services. For operators of a bigger size, scope economies can be still exploited by linking urban and intercity services or by linking intercity services and coach renting, whereas the couple urban service-coach renting is associated with strong diseconomies of scope. Our results can help policymakers (that must define the boundaries of the service area to be tendered) and firms (that, as a result of the ongoing liberalization process, have increased opportunities to invest in regulated and non-regulated passenger transport activities) to make informed decisions.

**Keywords:** Multi-Service Firms, Scope and Scale Economies, Composite Cost Function.  
**JEL Code:** L97, L5, L21, C3.

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## 1. Introduction

The passenger transport industry has a pervasive socio-economic and environmental impact and is a significant contributor to the national and regional economies of most developed and developing countries. According to the European Commission, the Italian bus and coach industry (which includes all urban and suburban land transport modes, such as motor bus, tramway, streetcar, trolley bus, and metro) was employing in year 2011 171,200 workers, with a turnover of about 11 EUR billion. This amounts to 8% of the turnover of the entire passenger and freight transport sector, and to 0.7% of Italy's GDP (European Commission, 2014). The operation of public transport services has a significant impact on the budget of territorial bodies, since in most cases the revenues from end users tickets and subscriptions are not sufficient to recover the cost of providing the service. In recent years, in order to introduce more efficiency, enhance productivity and reduce huge deficits, many countries have put in place reforms in which the institutional reorganization of the industry is combined with the design of new regulatory measures that foresee specific incentives to increase efficiency. For example, the Italian Government, faced with a situation in which bus operators were on average benefiting from subsidies as high as to cover 71% of their operating costs, introduced in the late nineties a radical reform which modified the institutional organization of the industry. In particular, the programming of the services and the management of the subsidies were shifted from the national to the regional level, and firms were required to sign formal agreements with local governments (*service contracts*) to clearly define the rules that the providers of the service must obey and to address important issues such as reimbursement and risk-sharing schemes. The above measures, together with the reliance on competitive tendering for the allotment of service concessions and the introduction of incentive mechanisms in the allocation of subsidies (e.g., through a *subsidy cap*), were supposed to improve efficiency and to enhance competition. New laws and decrees were introduced in the 2000s, and a Transport Regulation Authority was established in 2011.<sup>1</sup>

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<sup>1</sup> The Authority, that became fully operational in January 2014, defines the schemes for tendering and the contents of the service contracts, sets the criteria to fix tariffs, contributes to define public sector obligations, sets minimum quality standards, defines minimum rights and entitlements that may be claimed by passengers vis-à-vis transport operators.

However, a huge resistance movement to the reforms of local public services led to the setup of an abrogative referendum in 2011. Twenty-seven million citizens voted against the obligation of organizing call for tenders for the management of the services<sup>2</sup>, a result that involved a significant slowing down of the liberalization process.<sup>3</sup>

An effective reform of the industry cannot be implemented without a detailed analysis of the cost structure of bus and coach operators. In fact, the study of the economic and technological characteristics is a fundamental step, since it allows the identification of the proper configuration of the network and provides guidance if one wants to implement adequate regulatory interventions (if evidence is found in favor of natural monopoly) or to open the market to competition (if the empirical results show that natural monopoly conditions do not hold). Moreover, the definition of the optimal dimension of the local transport network represents a necessary starting point for an efficiency-oriented policymaker who is planning and designing the provision of the service (i.e., extension of the service areas, frequencies of buses, choice of the number of bus lines, etc.).

As stated by Karlaftis and McCarthy (2002) “*Characteristics of the underlying production technology of firms in regulated industries have attracted considerable interest in the literature due to the vast array of valuable information provided by such analyses. Policy makers and governmental agencies may be interested in the underlying production technology in order to set pricing policies. A finding of diseconomies of scale may imply that, for example, a city can have different parts of its system operated by separated companies at a lower unit cost of output*” (p.1-2).

The fact that operators are often multi-service firms, which operate in regulated markets such as urban and intercity transport and in non-regulated markets such as long distance express coach and hired coach services, is another interesting aspect that deserves careful investigation. As theoretically shown by Calzolari and Scarpa

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<sup>2</sup> Article 23-bis of decree-law no. 112/2008, which was abrogated as a result of the popular vote, outlined the public tender as a preferential model to manage local public services. In-house provision was admitted only as an exception, after having verified the existence of particular socio-economic conditions that made it impossible to resort to the market.

<sup>3</sup> The main concern of referendum organizers was to fight against the privatization process in the water sector. However, the abrogative effect was widespread to all local public services, including passenger transport.

(2016), if multiservice firms are exploiting scope economies, it is desirable from a social welfare point of view to let them run integrated productions activities in regulated and unregulated sectors.

Constant changes in the economic, social and environmental systems also require adaptation in the transportation structure. To that respect, coach services can represent an essential complement of regular transit systems (Talley, 2007). They can contribute to the development of a capillary network, in that they can be easily interconnected with other modes of transport. Unlike scheduled transport services purely geared to predetermined destinations on fixed and authorized routes<sup>4</sup>, hired coach travel is typically characterized by non-scheduled times and non-fixed routes. Given these characteristics, this service is mainly addressed to occasional users, as it occurs, for example, in the tourism sector. Conversely, long distance coach transport plays a crucial role in connecting the most dispersed part of the countries to major destinations. As a result of the liberalization process undergoing in most countries (European Commission, 2009), express long distance coach transport is growing exponentially so as to directly compete with railways and airlines services.<sup>5</sup>

Despite its increasing importance, coach renting activities received only little attention in the literature. In order to fill this gap, this paper analyses the cost function of a sample of Italian transit firms which are providers, in combination or as specialised units, of urban, intercity and for-hire transport services in the years 2008 to 2012. Given the presence in the sample of specialised, two-output and three-output firms, we can investigate the presence of economies of scope for multi-service firms. From a methodological point of view, we differ from the standard literature, which uses the Translog Cost Function or the Generalised (Box-Cox) Translog Cost Function, and we test the advantage of using the Composite Cost Function model introduced by Pulley and Braunstein (1992), which appears to be well suited to analyse the cost properties of multi-product firms.

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<sup>4</sup> The European Commission (2009) identifies as “special regular” coach services such as school and employee transport services, which operate on defined routes and at defined times, but provide for the carriage of specific types of passengers to the exclusion of others.

<sup>5</sup> See, for example, Beria et al. (2014) for Italy, Chen and Soo (2009), for Taiwan, Aarhaug and Fearnley (2016), for Norway, and Walter et al. (2011), for Germany.

The remaining of the paper is organised as follows. Section 2 shortly reviews the relevant empirical literature. Section 3 develops the Composite Cost Function model upon which is based the subsequent econometric analysis. Section 4 illustrates the main characteristics of our sample and shows some descriptive statistics concerning the variables included in the cost model. Section 5 presents the results of our estimates and Section 6 concludes.

## **2. Literature review**

Early studies on the analysis of costs in the transportation literature were mainly focused on the effects of diversification among different transit modes (such as motor-bus, rapid-rail, streetcar, trolley-bus, etc.) within the same urban area. Colburn and Talley (1992), for example, by analysing four modes of transport in urban systems find evidence of the presence of limited cost complementarities. Viton (1993), by investigating the processes of aggregation between different suppliers, show that cost savings resulting from mergers depend on the transport modes of the companies as well as on the number of firms involved in the merger. More recently, Farsi *et al.* (2007), exploring multi-modal transport systems, show that economies of scale and scope exist, and are therefore in favour of integrated multi-mode operations as opposed to unbundling.

In order to estimate scale and scope economies, which are key structural elements to define the technology behind an industry, the most popular method is to use a multi-output specification of the cost function. While scale economies are due to decreasing marginal costs and to the sharing of fixed costs, scope economies can be due to the use of similar equipment such as wires, overhead line, similar skills such as driving, management and network maintenance, and synergies in advertising, scheduling and ticketing.

As for scale economies, Gagnepain *et al.* (2011) report that a significant number of empirical studies are in line with a U-shaped average cost curve, exhibiting increasing returns to scale for smaller operators and decreasing return beyond a certain output level. As an example, Cowie and Asenova (1999) estimate that small companies (with a bus fleet of less than 200 vehicles) experience some economies of scale. Looking at a set of medium and large Italian municipalities, Cambini *et al.*

(2007) find evidence of economies of scale in most cases, suggesting that operators should operate on the entire system of urban network, without fragmentation of the service. They also argue that mergers between operators of neighbouring urban centres or between suppliers of urban and intercity transit services would be desirable in order to reduce operating costs.

In the literature, there are relatively few studies tackling the issue of the horizontal integration between urban and intercity services. Fraquelli *et al.* (2004) investigates the existence of scope economies by using in the estimation a set of dummy variables to distinguish between specialized companies (in urban or intercity service) and integrated operators, and find evidence of lower costs for integrated bus transport firms. Di Giacomo and Ottoz (2010) model the total cost function for multi-service Local Public Transport (LPT) companies. The results of the estimations highlight the presence of very mild scope economies (around 2%) between urban and intercity services. However, by decomposing the effects related to the sharing of fixed costs from the ones stemming from cost complementarities (i.e. relative to the variable costs component), they find that horizontally integrated firms can save up to 6.3% of fixed costs. The extent of scope economies tends to decrease as the firm size increases, and modest scale economies (of the order of 1.040) are also observed for the median firm.

More recently, Ottoz and Di Giacomo (2012), analysing the LPT system of a specific Italian region (Piedmont), provide empirical evidence of the impact on costs of different diversification strategies. In particular, they observe that diversification depends on ownership type. While privately-owned firms generally choose to diversify into transit-related activities offered in competitive markets (such as, for instance, rental bus services), publicly-owned bus companies are more likely to diversify in regulated businesses (such as electricity, water and sewerage, car parking management). Due to unavailability of data on supply-oriented output quantities (like travelled kilometres), they used revenue as proxy of the output of each activity. The authors present estimates from two cost functions, one with two outputs (local public transit, which includes both urban and intercity services, and a sum of transport-related and non-transport activities), and the other with three outputs (local public transit, transport-related and non-transport activities). The results show the presence of scope economies for the median firm which range



between 16% and 30%, depending on the cost function specification as well as on the number of outputs. Lower global scope economies are found for publicly-owned firms, and, more in general, for large operators. Finally, pairwise scope economies are found (16%) between core business transport services (urban plus intercity) and transport-related services.

To the best of our knowledge, no existing empirical research has estimated multi-product cost functions including hired coach, urban and intercity passenger services as *three separate outputs*.<sup>6</sup> This has been due also to severe limitations of available data.<sup>7</sup> The empirical analysis which is closest to the spirit of our study is indeed the above cited paper by Ottoz and Di Giacomo (2012), who estimate a cost function accounting for subsidized transport services (the sum of the vehicle-kilometres covered by buses in both urban and intercity areas), non-subsidized transport services (the vehicle-kilometres covered by hired coaches) and non-transport services (the share of total revenues stemming from activities such as parking, waste disposal and treatment, gas and electricity distribution, etc.).

### 3. The econometric cost function model

The availability of data on costs, outputs and inputs for Italian firms providing urban, intercity and for-hire bus transport allows us to undertake a detailed study of the cost function in order to detect the presence of aggregate and product-specific economies of scale and scope. According to the well-known *Generalized Translog (GT) Specification* (Caves et al., 1980), the cost function is given by:<sup>8</sup>

$$\begin{aligned} \ln C = & \alpha_0 + \sum_i \alpha_i y_i^{(\pi)} + \frac{1}{2} \sum_i \sum_j \alpha_{ij} y_i^{(\pi)} y_j^{(\pi)} + \sum_i \sum_r \delta_{ir} y_i^{(\pi)} \ln w_r \\ & + \sum_r \beta_r \ln w_r + \frac{1}{2} \sum_r \sum_l \beta_{rl} \ln w_r \ln w_l \end{aligned} \quad [1]$$

where  $C$  is the long-run cost of production,  $y_i$  refers to outputs (in our three-output case  $i, j = U, I, H$ ),  $w_r$  indicates factor prices (in our three-input case  $r, l = L, K$ ,

<sup>6</sup> For a more comprehensive review of the empirical literature dealing with the urban public transport sector, see Daraio et al. (2016).

<sup>7</sup> As stated by the European Commission: “Very little national statistics are available on long distance bus and coach services and in terms of both regulation and statistics, there is no distinction made between extra-urban services and local buses” (European Commission, 2009, p. 5).

<sup>8</sup> For convenience, we omit the subscript referring to individual observations.

MS), and the superscripts in parentheses  $\pi$  represent Box-Cox transformations of outputs.<sup>9</sup>

The associated input cost-share equations are obtained by applying the *Shephard's Lemma* to expression [1]<sup>10</sup>

$$S_r = \sum_i \delta_{ir} y_i^{(\pi)} + \beta_r + \sum_l \beta_{rl} \ln w_l \quad [2]$$

Setting  $\pi \rightarrow 0$  in [1] and [2] yields the nested *Standard Translog (ST) Specification*, with all output terms in the cost function and in the corresponding cost-share equations assuming the usual logarithmic ( $\ln y$ ) form.<sup>11</sup>

For small values of  $\pi$ , the estimated GT function is a close approximation to the ST functional form. Due to its log-additive output structure, the latter suffers from the well-known inability to evaluate cost behavior when any output is zero. This has been proved to yield unreasonable and/or very unstable values of the estimates for scope economies and product-specific scale economies (e.g., Pulley and Braunstein, 1992; Piacenza and Vannoni, 2004; Bottasso et al., 2011).

To overcome the above problems, Pulley and Braunstein (1992) proposed as an alternative functional form for multi-product technologies the *Generalized Composite (PB<sub>G</sub>) Specification*.

$$C^{(\phi)} = \left\{ \exp \left[ \left( \alpha_0 + \sum_i \alpha_i y_i^{(\pi)} + \frac{1}{2} \sum_i \sum_j \alpha_{ij} y_i^{(\pi)} y_j^{(\pi)} + \sum_i \sum_r \delta_{ir} y_i^{(\pi)} \ln w_r \right)^{(\tau)} \right] \cdot \exp \left[ \beta_0 + \sum_r \beta_r \ln w_r + \frac{1}{2} \sum_r \sum_l \beta_{rl} \ln w_r \ln w_l \right] \right\}^{(\phi)} \quad [3]$$

where  $C$  is the long-run cost of production,  $y_i$  and  $w_r$  refer to outputs and factor prices, respectively, and the superscripts in parentheses  $\phi$ ,  $\pi$  and  $\tau$  represent Box-Cox transformations.

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<sup>9</sup> We indicate the Box-Cox (1964) transformation for a generic output  $y_i$  as  $y_i^{(\pi)}$ , where  $y_i^{(\pi)} = (y_i^\pi - 1)/\pi$  for  $\pi \neq 0$  and  $y_i^{(\pi)} \rightarrow \ln y_i$  for  $\pi \rightarrow 0$ . Such a transformation allows to take into consideration observations for which the output  $y_i$  is equal to zero.

<sup>10</sup> Cost-shares are computed as  $S_r = (X_r P_r)/C$ . By Shephard's Lemma  $X_r = \partial C / \partial w_r$ , where  $X_r$  is the input demand for the  $r$ th input, so that  $S_r = \partial \ln C / \partial \ln w_r$ .

<sup>11</sup> In this case, zero values for any of the three outputs are replaced with 0.001.

By applying the *Shephard's Lemma*, one can easily obtain the associated input cost-share equations:

$$S_r = \left( \sum_i \delta_{ir} y_i^{(\pi)} \right) \cdot \left[ \alpha_0 + \sum_i \alpha_i y_i^{(\pi)} + \frac{1}{2} \sum_i \sum_j \alpha_{ij} y_i^{(\pi)} y_j^{(\pi)} + \sum_i \sum_r \delta_{ir} y_i^{(\pi)} \ln w_r \right]^{\tau-1} + \beta_r + \sum_l \beta_{rl} \ln w_l \quad [4]$$

Equation [3] embraces several of the most commonly used cost functions. The *Generalized Translog* (GT) and the *Standard Translog* (ST) models can be easily obtained by imposing the restrictions  $\phi=0$  and  $\tau=1$  (and  $\pi=0$  for the ST model). The *Composite Specification* (PB<sub>C</sub>) is a nested model in which  $\pi=1$  and  $\tau=0$ , while the *Separable Quadratic* (SQ) functional form requires the further restriction  $\delta_{ir}=0$  for all  $i$  and  $r$ . The PB<sub>G</sub> and PB<sub>C</sub> specifications originate from the combination of the log-quadratic input price structure of the ST and GT specifications with a quadratic structure for multiple outputs. This makes the model particularly suitable for the empirical cost analysis. The quadratic output structure is appropriate to model cost behavior in the range of zero output levels and gives the PB specifications an advantage over the ST and GT forms as far as the measurement of both economies of scope and product-specific economies of scale are concerned. In addition, the log-quadratic input price structure can be easily constrained to be linearly homogeneous.<sup>12</sup> In this paper, we estimate the system [3]-[4] and carry out LR tests in order to select the specification best fitting observed data. We then obtain estimates of aggregate and output-specific scale and scope economies for our sample of LPT firms. Finally, by fully exploiting the informational content of our specification, we investigate the presence of scope economies for couples of services.

Given the regularity conditions ensuring duality, the PB specifications do not impose a priori restrictions on the characteristics of the below technology. A more parsimonious and less general form is the *Separable Quadratic* (SQ) *Specification*, in which all terms  $\delta_{ir}$  are set equal to 0. The SQ function allows estimating the costs in the range of zero

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<sup>12</sup> To be consistent with cost minimization, [1] and [3] must satisfy symmetry ( $\alpha_{ij} = \alpha_{ji}$  and  $\beta_{rl} = \beta_{lr}$  for all couples  $i, j$  and  $r, l$ ) as well as the following properties: a) non-negative fitted costs; b) non-negative fitted marginal costs with respect to outputs; c) homogeneity of degree one of the cost function in input prices ( $\sum_r \beta_r = 1$  and  $\sum_l \beta_{rl} = 0$  for all  $r$ ,  $\sum_r \delta_{ir} = 0$  and  $\sum_l \beta_{rl} = 0$  for all  $i$ ); d) non-decreasing fitted costs in input prices; e) concavity of the cost function in input prices.

outputs, but has the disadvantage of imposing strong separability between outputs and inputs.

### 3.1. Measures of scale and scope economies

Assume the multi-product cost function to be represented by  $C = C(y; w)$ , where  $y = (y_U, y_I, y_H)$  and  $w = (w_L, w_K, w_{MS})$ . Local measures of global and product-specific scale and scope economies can be easily defined. *Global or aggregate scale economies* are computed via

$$SCALE_T(y; w) = \frac{C(y; w)}{\sum_i y_i MC_i} = \frac{1}{\sum_i \varepsilon_{Cy_i}} \quad [5]$$

where  $MC_i = \partial C(y; w) / \partial y_i$  is the marginal cost with respect to the  $i$ th output and  $\varepsilon_{Cy_i} = \partial \ln C(y; w) / \partial \ln y_i$  is the cost elasticity of the  $i$ th output.

The above measure describes the behavior of costs as all outputs increase by strictly the same proportion. However, since product mixes rarely remain constant as output changes, additional dimensions of scale behavior can be measured by product-specific scale economies indicators. These latter show how costs change as the output of one or two products changes with the quantities of other products held constant. *Product-specific economies of scale* for the couple of products  $(i, j; i \neq j)$  are defined by

$$SCALE_{ij}(y; w) = \frac{IC_{ij}}{y_i MC_i + y_j MC_j} = \frac{IC_{ij}}{[\varepsilon_{Cy_i} + \varepsilon_{Cy_j}] C(y; w)} \quad [6]$$

where  $IC_{ij} = C(y; w) - C(y_{-ij}; w)$  represents the incremental cost of the couple  $(i, j)$ , and  $C(y_{-ij}; w)$  is the cost of producing all the other products different from  $i$  and  $j$ .

The degree of scale economies specific to the product  $i$  are finally

$$SCALE_i(y; w) = \frac{IC_i}{y_i MC_i} = \frac{IC_i}{\varepsilon_{Cy_i} C(y; w)} \quad [7]$$

where  $IC_i = C(y; w) - C(y_{-i}; w)$  is the incremental cost relating to the  $i$ th product and  $C(y_{-i}; w)$  is the cost of producing all outputs except the  $i$ th one. Returns to scale defined by expressions [5], [6] and [7] are said to be increasing, constant or decreasing

as  $SCALE_T$ ,  $SCALE_{ij}$  and  $SCALE_i$  are greater than, equal to, or less than unity, respectively.

Scope economies (diseconomies) are reflected into cost savings (cost disadvantages) associated with the joint production of many outputs. The measure of *global* or *aggregate scope economies* for our three-output case can be computed via

$$SCOPE_T(y; w) = \frac{[C(y_U, 0, 0; w) + C(0, y_I, 0; w) + C(0, 0, y_H; w) - C(y; w)]}{C(y; w)} \quad [8]$$

with positive values of  $SCOPE_T$  representing global economies of scope and negative values global diseconomies of scope.

*Product-specific economies of scope* for output  $i$  are

$$SCOPE_i(y; w) = \frac{[C(y_i; w) + C(y_{-i}; w) - C(y; w)]}{C(y; w)} \quad [9]$$

where  $C(y_i; w)$  is the cost of producing only output  $i$ , and  $SCOPE_i$  indicates a cost disadvantage (if greater than zero), or a cost advantage (if lower than zero) in the “stand-alone” production of output  $i$ .<sup>13</sup>

Finally, it is also possible to assess the degree of economies of scope for couples of outputs under the assumption that the production of the remaining output is zero. Formally, scope economies for the couple of products  $(i, j; i \neq j)$  are defined by

$$SCOPE_{Cij}(y_{ij}; w) = \frac{[C(y_i; w) + C(y_j; w) - C(y_{ij}; w)]}{C(y_{ij}; w)} \quad [10]$$

with  $C(y_{ij}; w)$  denoting the cost of producing the outputs  $i$  and  $j$  alone.

The following relationship nicely highlights the links between aggregate and product specific scope economies:

$$SCOPE_T(y; w) = SCOPE_{Cij}(y; w) * \frac{C(y_{ij}; w)}{C(y; w)} + SCOPE_{-ij}(y; w) \quad [11]$$

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<sup>13</sup> In our three outputs case, the measure of product-specific economies of scope for the couple  $(i, j)$  is identical to the one for the remaining good  $k$  ( $SC_k = SC_{-ij}$ ):

$$SCOPE_k = SCOPE_{-ij} = SCOPE_{ij} = \frac{[C(y_{ij}; w) + C(y_{-ij}; w) - C(y; w)]}{C(y; w)}.$$

#### 4. Data description

We obtained data on costs, output quantities and input prices by integrating the information available in the annual reports of each company with additional information drawn from questionnaires sent to managers.<sup>14</sup> Long-run total cost ( $C$ ) is the sum of fuel and other raw materials and services, labor and capital costs of the firm. All monetary values are expressed in 2010 constant prices, using as a deflator the general production price index. The three output categories are: urban transit ( $y_U$ ), intercity transit ( $y_I$ ) and for-hire transit ( $y_H$ ). As shown by Daraio et al. (2016), an array of demand-oriented measures, such as passenger-trips or passenger-kilometers, and supply-oriented measures, such as vehicle-kilometers, seat-kilometers or total-seat kilometers have been used in the literature. Our measure, vehicle-kilometers, is the most popular in the empirical cost analysis.<sup>15</sup> As discussed in sections 1 and 2, it is difficult to disentangle bus and coach transport, on the one hand, and intercity and long distance services, on the other hand. In our data, coach services are partially included in the variables  $y_I$  and  $y_H$ . Rather than clearly distinguishing between coach and bus transport, we aim at separating occasional services and special regular services (which are both included in  $y_H$ ) from regular services (included in  $y_U$  and  $y_I$ ).

Productive factors are labor, capital, materials and services. The price of labor in each utility ( $w_L$ ) is given by the ratio of total salary expenses to the number of employees. Capital price ( $w_K$ ) is obtained by dividing the sum of amortization costs, interest payments and costs for the use of third party goods by the total number of vehicles.<sup>16</sup> Finally, the price of material and services ( $w_{MS}$ ) is the cost of fuel and

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<sup>14</sup> Data were gathered in teamwork with the two main Italian category associations: ANAV (Associazione Nazionale Autotrasporto Viaggiatori) and ASSTRA (Associazione Trasporti).

<sup>15</sup> Daraio et al. (2016), selected and reviewed 31 studies focusing on the cost function estimation of local public transport companies. As they reported in Table 6 (page 11), vehicles-kilometer was used as an output measure in 57% of the cases. Seat-kilometers and passenger kilometers were two other popular measures (27% and 17% of cases, respectively).

<sup>16</sup> In a previous version of this paper, we used operating cost as a left hand side variable. In practice, total cost was not including interest payments and  $w_K$  was simply computed by dividing the amortization costs by the total number of vehicles. As suggested by a referee, by including interest payments and leasing charges, we end up with a more meaningful and better measure of the true cost of capital. We thank the referee for having raised this issue.

other raw materials (spare parts, tyres) and services (including maintenance) per liter of fuel consumption.<sup>17</sup> Summary statistics are provided in Table 1.

The dataset is an unbalanced panel of 47 firms observed during the years 2008-2012, for a total of 147 observations. 30 observations refer to specialized firms, while 9 observations refer to fully integrated firms. The vast majority is however represented by firms performing a couple of services, in particular intercity and for-hire services, or intercity and urban. As shown in Table 1, the average firm is endowed with a bus fleet of around 150 buses and employs around 300 workers.<sup>18</sup>

## 5. Estimation and empirical results

All the specifications of the multi-product cost function are estimated jointly with their associated input cost-share equations. Because the three share equations sum to unity, to avoid singularity of the covariance matrix the capital share equation ( $S_K$ ) was deleted and only the labor equation ( $S_L$ ) and the materials and services equation ( $S_{MS}$ ) were included in the systems.<sup>19</sup> Before the estimation, all variables were standardized on their respective sample means, and regional and time dummies were included in all regressions.<sup>20</sup> Assuming the error terms in the above models are normally distributed, the concentrated *log-likelihood* for the estimated *cost function* and related *labor-share equation* and *material-share equation* can be respectively computed via

$$\ln L_C = -\sum_{t=1}^T \ln C_t - \frac{T}{2} [1 + \ln(2\pi)] - \frac{T}{2} \ln \left[ \frac{1}{T} \sum_{t=1}^T \hat{\psi}_{C_t}^2 \right] \quad [12]$$

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<sup>17</sup> In a set of non-reported regressions, we have excluded services from the computation of the residual input, in order end-up with a set of “distance related” cost components. The results of estimations, which are very similar to the one reported in the next section, are available upon request. We are indebted to an anonymous referee for having raised this issue.

<sup>18</sup> The figures reported in Table 1, with the exception of  $y_U$ ,  $y_I$  and  $y_H$ , refer to all 147 observations, so that, as an example, 24.373 million euros refers to the yearly total cost of a hypothetical average firm, and so on.

<sup>19</sup> We have tested models with four inputs, where fuel (which accounts, on average, for 18.5% of total costs) was considered as a separate input. Results are very similar and are available upon request.

<sup>20</sup> Parameter estimates were obtained via a non-linear GLS estimation (NLSUR), which is the non-linear counterpart of the Zellner’s iterated seemingly unrelated regression technique. This procedure ensures estimated coefficients to be invariant with respect to the omitted share equation (Zellner, 1962).

$$\ln L_{S_L} = -\frac{T}{2}[1 + \ln(2\pi)] - \frac{T}{2} \ln \left[ \frac{1}{T} \sum_{t=1}^T \hat{\psi}_{L_t}^2 \right]$$

$$\ln L_{S_{MS}} = -\frac{T}{2}[1 + \ln(2\pi)] - \frac{T}{2} \ln \left[ \frac{1}{T} \sum_{t=1}^T \hat{\psi}_{MS_t}^2 \right]$$

where  $t$  is the single observation ( $t = 1, \dots, 147$ ),  $\hat{\psi}_C, \hat{\psi}_L$  and  $\hat{\psi}_F$  are the estimated residuals of the two regressions, and  $(-\Sigma_t \ln C_t)$  is the logarithm of the Jacobian of the transformation of the dependent variable from  $C_t$  to  $\ln C_t$  ( $J = \prod_{t=1}^T J_t$  with  $J_t = |\partial \psi_{C_t} / \partial C_t| = 1/C_t$ ). Similarly, the concentrated *system log-likelihood* is defined by:

$$\ln L_{(C, S_L)} = \ln J - \frac{T}{2} [2(1 + \ln(2\pi)) + \ln |\Omega|] \quad [13]$$

Where  $J$  is the Jacobian of the transformation of  $(C_t, S_{L_t}, S_{MS_t})$  into  $(\ln C_t, S_{L_t}, S_{MS_t})$ , and  $\Omega$  is the  $(3 \times 3)$  matrix of residual sum of squares and cross products for the system, where the  $pq$ th element of  $\Omega$  ( $\Omega_{pq}$ ) is equal to  $\frac{1}{T} \sum_{t=1}^T \hat{\psi}_{p_t} \hat{\psi}_{q_t}$  and  $p, q = C, S_L, S_{MS}$

The summary results of the NLSUR estimations for the ST, GT, SQ, and PB models are presented in Table 2. In the first row the value of the Box-Cox parameter ( $\pi$ ) for the GT specification is positive (0.1987) and significantly different from zero (t-ratio = 5.482). The small value of  $\pi$  suggests that, being a close approximation to the standard translog form, the GT model would suffer from the same drawbacks of the ST specification when used to estimate cost properties of multi-product firms. The estimates of the three “box-cox” parameters are all significantly different from zero, and suggest that restricting them to be equal to some specific values (one or zero, according to the four nested specifications PB<sub>C</sub>, SQ, GT and ST) may result in an imprecise estimation of technological parameters.

The following five rows present the estimates of cost elasticities with respect to outputs and factor prices for the ‘average’ firm.<sup>21</sup>

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<sup>21</sup> The *average* firm (the point of normalization) corresponds to a hypothetical firm operating at an average level of production for each output and facing average values of the input price variables.



While the four estimated cost function models seem to perform similarly with respect to input-price elasticities (which are close to the observed input cost shares reported in Table 1), the estimates for the output elasticities show a greater variability, with SQ and PB models according more weight to the urban service. The  $R^2$  for the cost function and for the cost-share equations are very similar, except for the SQ specification. The lower ability of the SQ specification to fit the observed factor-shares is not surprising given that it assumes a strong separability between inputs and outputs. McElroy's (1977)  $R^2$  ( $R^{*2}$ ) can be used as a measure of the goodness of fit for the NLSUR system. The results suggest that the fit is slightly lower for the ST ( $R^{*2} = 0.97$ ) and GT ( $R^{*2} = 0.96$ ) functional forms.

Since the  $PB_C$ , SQ, GT and ST models are all nested into the  $PB_G$  specification, standard likelihood ratio (LR) hypothesis testing based on system log-likelihoods can be applied to see which model adjusts better observed data. The LR statistics lead to reject the ST and GT specifications (critical  $_{0.01}\chi^2_{(3)} = 11.34$ ; computed  $\chi^2_{(3)} = 215.42$  for the ST model and critical  $_{0.01}\chi^2_{(2)} = 9.21$ ; computed  $\chi^2_{(2)} = 225.34$  for the GT model). Similarly, the null hypothesis that  $PB_G$  and SQ models are equally close to the true data generating process is rejected in favor of the  $PB_G$  specification (critical  $_{0.01}\chi^2_{(2)} = 9.21$ ; computed  $\chi^2_{(2)} = 144.63$ ). However, the restricted composite model  $PB_C$  cannot be rejected (critical  $_{0.01}\chi^2_{(2)} = 9.21$ ; computed  $\chi^2_{(2)} = 7.72$ ).

The estimates of scale economies for the average firm in the sample are similar across models (except for the GT model where the estimate is larger), and suggest that the average firm is exhibiting constant returns to scale (all figures, except for the SQ model, are not statistically different from one). This finding is consistent with Gagnepain and Ivaldi (2011), with Di Giacomo and Ottoz (2010), considering that the average firm in their sample has a fleet size of 50 vehicles (i.e. one third of the size of our sampled firms), as well as with the results of a study of the UK Competition Commission, that concluded that small-scale bus operators are not likely to be significantly disadvantaged by higher costs relative to larger-scale operators (Competition Commission, 2011).

The relative advantages of the composite specification can be best appreciated by comparing the measures of global economies of scope. In the ST (GT) specification

the average firm exhibits scope diseconomies of the order of -27% (-21%), while the  $PB_G$ ,  $PB_C$  and  $SQ$  models all point towards the absence of economies of scope. This is in line with expectations, since the  $ST$  cost model, as well as the  $GT$  specification for small values of the Box-Cox parameter (in this case  $\pi = 0.1987$ ), often provide unreasonable and/or very unstable estimates when outputs are set near to zero.<sup>22</sup>

The preference for the composite specification on the base of statistical fit and as a result of  $LR$  based statistics is thus further strengthened by the better ability of quadratic models in measuring global scope economies. In the remaining of the paper we will then focus on the  $PB_G$  functional form in carrying out the empirical tests concerning scope and scale economies.<sup>23</sup>

### 5.1. Global and product specific economies of scale and scope

Table 3 reports the estimates for global scale and scope economies evaluated at the output sample means,  $y^* = (y^*_U, y^*_I, y^*_H)$ , and at ray expansions and contractions of  $y^*$ . More precisely, we consider the following output scaling:  $\lambda y^* = (\lambda y^*_U, \lambda y^*_I, \lambda y^*_H)$ , with outputs ranging from one fourth ( $\lambda=0.25$ ) to four times ( $\lambda=4$ ) the values observed for the ‘average’ firm. The results show the presence of aggregate economies of scale ( $SC_T = 1.15f$  for  $\lambda=0.25$ ) and economies of scope ( $SCOPE_T = 0.29$  for  $\lambda=0.25$  and  $0.13$  for  $\lambda=0.5$ ) for small firms, while for firms larger than the average, economies of scope are absent and decreasing returns to scale appear.

By looking more deeply into the contribution of each product or couples of products in determining the above global scope and scale economies results, it emerges that scope economies are mostly driven by the presence of the intercity bus service, since both  $SCOPE_I$ ,  $SCOPE_{CUI}$  and  $SCOPE_{CHI}$  are positive and significant at most different size levels.

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<sup>22</sup> In a similar vein, the  $ST$  and  $GT$  models provide estimates for product specific scale and scope economies which are very implausible.

<sup>23</sup> The estimated  $PB_G$  cost function also satisfies *each* of the output and price regularity conditions at 90 percent of the sample data points. More precisely, fitted costs are always non-negative and non-decreasing in input prices (fitted factor-shares are positive at each observation). Concavity of the cost function in input prices is satisfied everywhere in the sample (the Hessian matrix based on the fitted factor-shares is negative semi-definite). Fitted marginal costs with respect to each output are non-negative for 138 observations out of 147.

Up to  $\lambda=2$  (i.e. when the bus fleet is lower than 300 buses and the number of workers is less than 600), a firm which is active in urban transport or in coach renting (or both), can benefit from cost synergies if it adds the intercity bus service. As far as the size of the firm increases, these synergies remain only for the pairwise combination of urban and intercity service. Conversely, the negative values of  $SCOPE_{CHU}$ ,  $SCOPE_U$  and  $SCOPE_H$  suggest that for large firms it is better to run hire coach services and urban transport as separate activities.

Borrowing from the sports betting terminology, we can conclude that *triples* (i.e. the joint provision of urban, intercity and for-hire services) do not seem to be good strategies in terms of costs, whereas pair-wise combinations (doubles) of urban and intercity services, on the one hand, or intercity and coach hire services, on the other hand, can represent sound diversification strategies. The ‘*double*’ linking urban services and coach hire, on the contrary, does not appear to be a wise ‘bet’.

## 5.2. Discussion and policy implications

According to our estimates, the average firm in our sample exhibits constant aggregate returns to scale and is characterized by the absence of global scope economies. For smaller firms, the presence of scope economies for the intercity service leads to both aggregate scope economies and aggregate scale economies. For firms larger than the average, the presence of output specific decreasing returns to scale<sup>24</sup> counterbalances the effect of output specific scope economies, so that the final result is the absence of global scope economies (see equation 11) and the presence of decreasing aggregate returns to scale.

Therefore, our results suggest that firms for which the core business is urban transport can benefit from diversifying into intercity services, while firms specialized in intercity services can exploit scope economies by diversifying into coach renting services, but a diversification strategy which involves all three activities is not beneficial (except for very small operators).

A number of interesting policy implications emerge. Within the context of local transit systems, especially in the urban case, the possibility to increase outputs

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<sup>24</sup> The results for product specific economies of scale ( $SCALE_i$ ) point to the presence of constant returns to scale up to  $\lambda=1$ , and decreasing returns to scale for operators of larger sizes. However, the estimates for couples of products ( $SCALE_{ij}$ ) show that returns to scale are constant at all firm sizes, except for the couple  $y_U$ - $y_H$ , where they are decreasing for big operators.

might be rather limited unless firms diversify towards other similar activities. The diversification towards intercity and also for-hire services should be considered as a valid option in small environments, when the size of the urban area does not allow public transport firms to reach a minimum dimension. On the other hand, the demand for mobility in large metropolitan areas creates the conditions for having separate operators providing urban, intercity or for-hire services. As to for-hire services, their peculiar characteristic due to non-scheduled times and non-fixed routes do not favor too much their integration with other transit services. Nonetheless, for small companies, the integration might still be a viable solution, especially when the more competitive environment faced in rental coach sector makes it difficult to grow in the core activity. Intercity services represent the activity that can more easily be coupled with either urban or for-hire services.

There is some anecdotal evidence of firms' strategies that follow paths which are consistent with our findings. For example, in the city of Turin, the urban activities of ATM and the suburban activities of SATTI were merged in a new entity named GTT, which is consolidating its presence in the urban and intercity services and is at the same time divesting the subsidiaries involved in coach renting. To take another example, Arriva (a multinational UK transport company, acquired by Deutsche Bahn in 2010) started an aggressive acquisition campaign of intercity operators in northern Italy (among which SADEM in Piedmont, SAB in Lombardy, SADVA in Aosta Valley), operators which provide also coach renting services. Policy makers in charge of organizing competitive tendering must choose the proper configuration of the network to be put to tender. One option is to fragment the network in sub-basins, and open separate tenders for different quarters of a town, another option is relying on single tenders for the entire municipal area, eventually including also suburban areas and intercity connections. While the fragmentation of the service area and the unbundling of urban and intercity services lowers the barriers to market entry and may stimulate the participation of specialized and small companies as bidders, they may lead to higher bidding prices (i.e. higher costs), since the synergies in the joint production can no longer be exploited. Our findings, on the one hand, point towards the presence of substantial scope economies between urban and intercity services, and are therefore in support of integrated urban-intercity tenders. However, since intercity transport could be

conveniently coupled also with hiring services, the hypothesis of tendering specific intercity routes should not be excluded a priori, in light of a scenario where intercity routes are contended competitively by both urban transit firms and for-hire coach companies. The latter would instead be discouraged to participate in tendering that involves both urban and intercity services (because of scope diseconomies between urban and for-hire outputs). This scenario might be evaluated carefully especially in large metropolitan areas, where the creation of sub-basins might be a viable solution, given that scale economies tend to exhaust at relatively low output levels. Of course, since our paper focuses exclusively on supply side factors, a cautionary note is necessary. In fact, the policy maker should take into consideration also demand-side factors such as population size and structure, network effects, ticketing strategies of operators, and so on.

## **6. Conclusions**

In this paper, using a sample of Italian bus and coach companies observed for the years 2008-2012, we explore the presence of scale and scope economies in the passenger transport sector. Using a Composite Cost Function econometric model (Pulley and Braunstein, 1992), which allows to disentangle potential synergies emerging when firms provide different combinations of three types of transit services (urban, intercity and for-hire) we find that small multi-service firms may benefit from cost reductions with respect to specialized operators. As the size of the firm increases, the cost savings remain only for the intercity bus service, while both output specific and aggregate decreasing returns to scale emerge.

Therefore, we find that for operators of a bigger size, scope economies can be still exploited by linking urban and intercity services or by linking intercity services and coach renting. Conversely, the joint provision of urban service and coach renting is associated with strong diseconomies of scope.

Our results can help policymakers (that must choose the boundaries of the service area to be tendered) and firms (that, as a result of the ongoing liberalization process, have increased opportunity to invest in regulated and non-regulated passenger transport activities) to make informed decisions.

The presence of scope economies between urban and intercity transport are in favor of bundling in a single tender the two services (especially in situations in which there are large metropolitan areas surrounded by satellite or edge cities), while the synergies between intercity transport and coach renting can be fruitfully exploited by firms that are seeking to expand their activities in the passenger transport industry. In some circumstances (for example in regions characterized by different relatively small urban centers), a viable solution could also be that of establishing separate tender procedures for the intercity service, so as to enable the participation of both urban operators and coach renting companies as bidders. This will leave the market free to undertake the desired aggregations.

**Table 1. Summary Statistics**

	Mean	Std. dev.	Min	Median	Max
<i>Operating Cost</i> (10 <sup>6</sup> Euros)	24.373	60.159	0.275	6.489	499.328
<i>Total Cost</i> (10 <sup>6</sup> Euros)	24.567	60.499	0.277	6.562	502.110
<i>Output and Input</i>					
$y_U$ - Urban (10 <sup>6</sup> kilometers)	11.202	11.900	2.190	8.300	56,740
$y_I$ - Intercity (10 <sup>6</sup> kilometers)	3.403	4.857	0.090	1.545	22,060
$y_H$ - For-hire (10 <sup>6</sup> kilometers)	0.852	0.753	0.010	0.610	3,500
Workers	305.463	705.107	2	91	5,499
Bus and Coaches	148.041	255.563	7	57	1,832
<i>Input prices</i>					
$w_K$ - Price of capital (10 <sup>3</sup> Euros)	18.595	11.195	2.550	17.184	61.988
$w_{MS}$ - Price of materials and services, including fuel (Euros per liter)	2.893	0.923	1.570	2.630	5.960
$w_F$ - Price of fuel (Euros per liter)	1.458	0.491	0.765	1.326	3.247
$w_L$ - Price of labor (10 <sup>3</sup> Euros)	38.942	6.221	23.824	38.708	50.455
<i>Cost shares</i>					
$S_K$ - Capital share	0.185	0.083	0.046	0.163	0.460
$S_{MS}$ - Materials and services share	0.355	0.103	0.159	0.343	0.592
- of which $S_F$ - Fuel share	0.185	0.053	0.087	0.186	0.322
$S_L$ - Labor share	0.460	0.118	0.202	0.476	0.696

**Table 2. NLSUR estimation: Standard Translog (ST), Generalized Translog (GT), Separable Quadratic (SQ), and Composite (PB) cost function models <sup>a</sup>**

	PB <sub>G</sub> MODEL	PB <sub>C</sub> MODEL	SQ MODEL	GT MODEL	ST MODEL
<i>Box Cox Parameters</i>					
$\pi$	0.9939*** (0.1665)	1	1	0.1987*** (0.0362)	0
$\tau$	-0.1506*** (0.0354)	0	0	1	1
$\theta$	0.5562*** (0.0364)	0.6289 *** (0.0472)	0.4972*** (0.0565)	0	0
<i>Output and factor price elasticities <sup>b</sup></i>					
$\mathcal{E}_{Cy_U}$	0.6232*** (0.0377)	0.6187*** (0.0167)	0.6204*** (0.0136)	0.3383*** (0.0758)	0.3811*** (0.0820)
$\mathcal{E}_{Cy_I}$	0.40426*** (0.0751)	0.3141*** (0.0248)	0.3282*** (0.0216)	0.3253*** (0.1126)	0.5420*** (0.0969)
$\mathcal{E}_{Cy_H}$	0.0627 (0.0927)	0.1222*** (0.0292)	0.1245*** (0.0293)	0.2457 (0.1698)	0.1278 (0.1434)
$S_L$	0.5386*** (0.0216)	0.5364*** (0.0155)	0.4501*** (0.0088)	0.5054*** (0.0398)	0.5174*** (0.0302)
$S_{MS}$	0.2993*** (0.0246)	0.3036*** (0.0187)	0.3598*** (0.0087)	0.3425*** (0.0368)	0.3388*** (0.0336)
<i>Global scale and scope economies <sup>b</sup></i>					
<b>SCALE<sub>T</sub></b>	0.9173 (0.0662)	0.9478 (0.0326)	0.9318*** (0.0199)	1.0997 (0.1594)	0.9515 (0.0930)
<b>SCOPE<sub>T</sub></b>	-0.0201 (0.0792)	0.0294 (0.0393)	-0.0361 (0.0299)	-0.2098 (0.2053)	-0.2707** (0.1192)
$R^2$ Cost function	0.9965	0.9965	0.9966	0.9837	0.9886
$R^2$ Labor share equation	0.6635	0.6534	0.3611	0.7077	0.7088
$R^2$ Material share equation	0.4951	0.4627	0.1999	0.5475	0.5540
System log-likelihood	488.315	484.456	416.001	375.643	380.607
Goodness of fit <sup>c</sup>	0.9900	0.9908	0.9906	0.9598	0.9690
LR test statistic	-	PB <sub>G</sub> vs. PB: LR = 7.72	PB <sub>G</sub> vs. SQ: LR = 144.63	PB <sub>G</sub> vs. GT: LR = 225.34	PB <sub>G</sub> vs. ST: LR = 215.42

<sup>a</sup> Estimated asymptotic standard errors in parentheses. \*\*\* Significant at 1%, \*\* Significant at 5%, \* Significant at 10%.

<sup>b</sup> The values are computed for the average firm. The coefficient subscripts are  $U$  = urban,  $I$  = intercity,  $H$  = for-hire,  $L$  = labor,  $MS$  = materials.

<sup>c</sup> The goodness-of-fit measure for the NLSUR systems is McElroy's (1977)  $R^2$ .

**Table 3. Estimates of economies of scope and scale for the PB<sub>G</sub> model by scaled values of the average outputs (at the average prices)<sup>a</sup>**

	<i>SCALE<sub>T</sub></i>	<i>SCOPE<sub>T</sub></i>	<i>SCOPE<sub>H</sub></i>	<i>SCOPE<sub>U</sub></i>	<i>SCOPE<sub>I</sub></i>	<i>SCOPE<sub>CHU</sub></i>	<i>SCOPE<sub>CHI</sub></i>	<i>SCOPE<sub>CUI</sub></i>
Scaling procedure								
$\lambda = 0.25$	1.1465* (0.0847)	0.2889** (0.1315)	0.1312** (0.0648)	0.1382** (0.0654)	0.1581** (0.0671)	0.1914** (0.0893)	0.3081*** (0.1155)	0.1633** (0.0674)
$\lambda = 0.5$	1.0328 (0.0359)	0.1338* (0.0732)	0.0389 (0.0353)	0.0537 (0.0362)	0.0957** (0.0411)	0.0566 (0.0518)	0.1815** (0.0801)	0.1010** (0.0416)
$\lambda = 1$	0.9173 (0.0662)	-0.0201 (0.0792)	-0.0409 (0.0263)	-0.0115 (0.0232)	0.0719** (0.0329)	-0.0616 (0.0389)	0.1004* (0.0599)	0.0788*** (0.0291)
$\lambda = 2$	0.8640*** (0.0289)	-0.0552 (0.0405)	-0.1312*** (0.0444)	-0.0764** (0.0338)	0.0788* (0.0461)	-0.1816*** (0.0563)	0.0561 (0.0825)	0.0936*** (0.0342)
$\lambda = 4$	0.7732*** (0.0362)	-0.1418 (0.1148)	-0.2484*** (0.0713)	-0.1545*** (0.0548)	0.1115 (0.0750)	-0.3086*** (0.0728)	0.0369 (0.1499)	0.1554** (0.0613)

<sup>a</sup> Estimated asymptotic standard errors in parentheses. Parameter  $\lambda$  refers to the coefficient used to scale down ( $\lambda = 0.25, 0.5$ ) and up ( $\lambda = 2, 4$ ) the average values of the three outputs.

\*\*\* Significant at 1%, \*\* Significant at 5%, \* Significant at 10%.

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